Subject NAL pp STORAGE RINGS 100 GeV

Very High Energy Cosmic Ray Experiments

Take approach of looking at cosmic-ray experiments and see if they can suggest experiments to be done with pp 200 GeV c.m. energy.

The basic point is that 200 GeV c.m. energy is equivalent to 20 TeV incident laboratory energy. This corresponds to the ultra-high-energy region in cosmic-ray work.

My source of information is Koshiba SJC-P-67-7 (rapporteur paper - Tenth Int. Conf. on Cosmic Rays 1967).

There appear to be two models for high-energy jets--the 2 fireball model and the isobar-pionization model.

The latter one appears to be favored at present, though the evidence is rather slim. Basically when the 2 nucleons collide there is an "evaporation" of a large number of mesons at large cm angles, and emission of nucleon isobars at small cm angles. The proposed experiment is to look for these isobars. I find it difficult to get excited at present about the 20 mesons emitted at all angles in these collisions (it should be mentioned that the secondary multiplicity is not well established and could be long W or $W^{1/2}$ and the pp rings could determine the correct law as a constraint on any model of production).

The Tokyo cosmic-ray group analyzed the isobars emitted and came up with rather firm constraints - the isobar was christened χ (aleph) with mass = 2 ± 0.05 GeV/c^2. I-spin = $\frac{1}{2}$, half-integral spin, decays into Nϕ (70%) and Nη (30%), with production probability increasing from 10^{-3} at E $\lesssim$ 30 GeV to 1 for E_o> 10 TeV. I find it hard to believe in such a solution, but they do not claim it to be unique. It at least indicates that the subject is worth experimentation under the more controlled situation of machines.

This is an extreme case of experimentation without having a particular theory to test. There are indications that something unexpected is happening in very high-energy cosmic ray interactions - e.g.the Utah experiments on angular distributions of 1 TeV muons and multiple parallel high-energy muons.

Without more detailed information I can only give very general ideas for the apparatus which might be involved. The important thing would be to have momentum analysis around the beam lines. I think one would want to accept angles up to 0.1 rad about the beam line with the capability of momentum analyzing mesons from 1 GeV/c up and protons to 50 GeV/c. One would want a central field partly because it is easier and cheaper to make one magnet for the two proton directions. It is also desirable to get the relatively low-momentum particles out of the vacuum as soon as possible --this would allow time of flight separation of mesons say up to 3 GeV/c ($\Delta t = t_\pi - t_k$ = Ins. for 30 m flight path at 3 GeV/c) etc. This magnet might have BL~20 kG-m. Then one would need 100 kG-m on the two proton legs for high-momentum protons, relatively small aperture and high precision. One also needs the corresponding 120 kG-m of compensation to restore the equilibrium orbits. As an aside it is desirable that the intersection line tangent does not coincide with the equilibrium orbits, so that neutral particles can be detected without interfering with the storage-ring structure.

Philosophical Thoughts:

There are a very large number of alternative possibilities to the above: one extreme is a 10 x 10 x 10 m^3 central field with say 15 kG, as open a structure as possible. Another extreme is to have no central field but only small angle magnets in the 2 legs, and surround the central region with $\sim 4\pi$ of wire chambers and total absorption nuclear counters, etc. if one is not interested in the final details of all the secondaries.

I suspect that only one very large magnet system would be built, so its parameters would have to be optimized for many different experiments, without knowing the details of the proposed experiments when the magnet system was designed. This would force one to design the biggest, most general purpose system that could be afforded. The particular interaction region in which it was placed would then become a relatively inflexible, permanent facility. It would then be sensible to consider other interaction regions (definitely more than one!) as flexible, "plug-in" 100 m long experimental devices.

It appears that this question of big magnetic systems is one of the basic problems since such a device is very expensive and interacts strongly with the storage rings. The most sensible approach to the problem might be to consider in some detail fairly specific experiments to find out if they can be combined into one major facility without too much trouble. If not a decision has to be made on whether to build a facility and then make experiments fit it, or to design a number of experiments each with its own, presumably smaller, analyzing device.

Note:

Consideration has to be given to the thickness of walls in the storage rings. A zero order guess at wall thickness gives 0.2 mm as a maximum for high-resolution work. If the pipe is kept small in diameter (~5 cm) then the conductance limit will tend to force one to strip sublimators and cryopumping, which are not very compatible with minimum wall thickness. Also there will probably have to be clearing electrodes along the 80 m of pipe. Details like heating the vacuum pipes to 300° C and protecting miscellaneous pieces of apparatus from such temperature extremes have to be carefully considered.